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THE REACTIONS OF 4,5-DEHYDROTROPONE WITH MORPHOLINE ENAMINES. [2+2]CYCLOADDITION REACTION OF DEHYDROTROPONE

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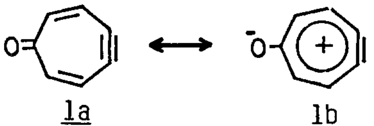
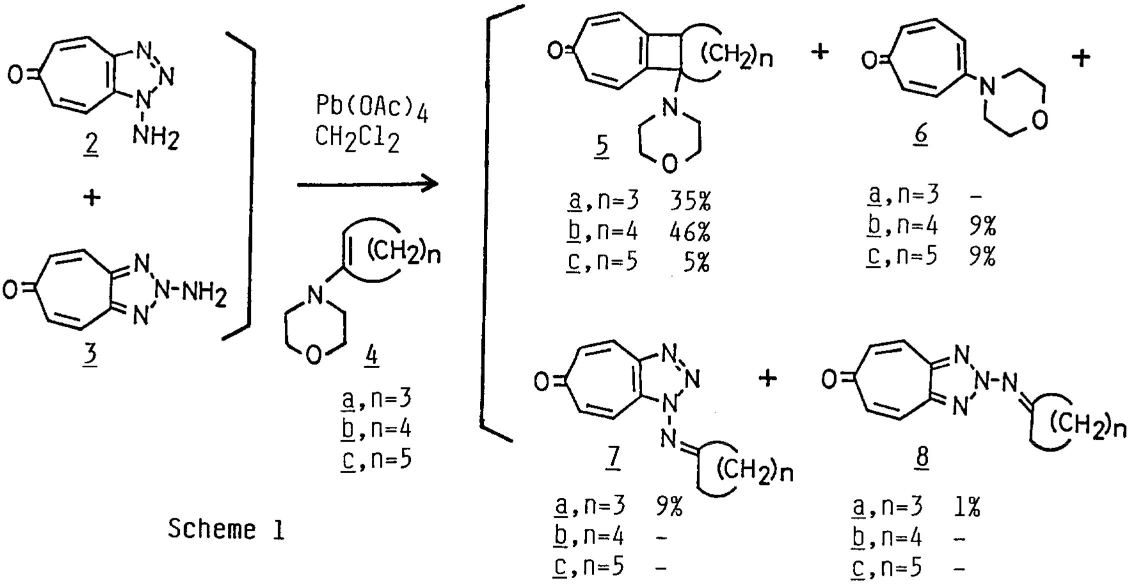
Abstract: The reactions of 4,5-dehydrotropone (1) with several 1-morpholino-1-cycloalkenes, the first examples of [2+2]cycloaddition reactions of 1, are described and some spectral characteristics of [2+2]cycloadducts obtained are discussed.

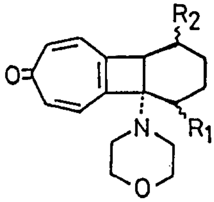
We have found the oxidative method for generation of 4,5-dehydrotropone (1)[2a] and have studied on the reactivities of 1 and application of them to the synthesis of tropones, heptafulvenes and tropylium ions incorporated into bridged systems.[2] From these investigations it has been revealed that 1 undergoes [4+2]cycloadditions with 1,3-dienes in relatively good yield; however, neither products derived from ene reactions nor those from [2+2]cycloaddition reactions, known in benzyne chemistry, were obtained.[3] The high yield (95 %) of [4+2]cycloadduct of 1 with oxepine[2b] suggested the increased reactivities of 1 to electron-rich olefins due to the presence of low energy LUMO as in the case of benzyne[4] and/or due to the possible contribution of a dipolar structure 1b to the ground state of 1a to some extent. In this connection, the present communication describes the reactions of 1 with some morpholine enamines employed as electron-rich olefins.


1a 1b

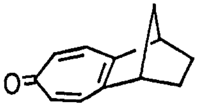
Since 1-amino-6H-cycloheptatriazol-6-one (2), the precursor of 1, and 2-amino-6H-cycloheptatriazol-6-one (3), prepared by amination of 6H-cycloheptatriazol-6-one,[2a] could not easily be separated, a mixture of 2 and 3 (mol ratio; ≃ 1 : 0.9) was treated with an equivalent lead tetraacetate in anhydrous dichloromethane in the presence of excess morpholine enamine under nitrogen at -30 °C for 10 h. The products were separated by column chromatography on basic alumina with hexane-ethyl acetate (3:1 ~ 1:1) and finally with ethyl acetate. As shown in Scheme 1, the expected [2+2]cycloadducts, 5a,b,c, were obtained in all cases of the enamines, 4a,b,c, but the products distributions varied with them used. The products 7a and 8a[5,6] are derived from condensation of the starting amines



Scheme 1



9, R_1=CH_3,R_2=H
10, R_1=H,R_2=CH_3



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2 and 3 with cyclopentanone formed by partial hydrolysis of 4a and/or amine exchange reaction of 4a with 2 and 3 catalyzed by acids.[7] Obviously, the product 6[8] comes from the addition of 1 with morpholine formed as described above. The structures of 5 were confirmed through their spectral characteristics as follows: 5a, a yellow oil; MS m/z, 257.1446 (M^+, $C_{16}H_{19}NO_2$); UV (MeOH) λmax (log ε) 232 (4.27), 324 nm (4.04); IR (film) 1622, 1564, 1556, 1531 cm^{-1} (tropone C=C, C=O), 1200, 1118 cm^{-1} (C-O); ^1H NMR ($CDCl_3$) δ 1.12-2.07 (6H, m), 2.52-2.90 (4H, m), 3.66-3.80 (4H, m), 3.52 (1H, m), 7.00 (4H, s-like); ^{13}C NMR ($CDCl_3$) δ 23.3, 26.6, 29.4 (each t, $-CH_2-$ of cyclopentane ring), 48.4 (d, $-\overset{|}{C}H-$), 49.1 (t, $-CH_2-\overset{|}{N}-$), 66.7 (t, $-CH_2-O-$), 78.6 (s, $-\overset{|}{\underset{|}{C}}-$), 131.9, 132.4, 142.0, 143.4 (each d, =CH-), 149.1, 151.4 (each s, $=\overset{|}{C}-$), 187.4 (s, C=O). 5b, a pale yellow oil; MS m/z, 271.1504 (M^+, $C_{17}H_{21}NO_2$); UV (MeOH) λmax (log ε) 232 (4.26), 324 nm (4.07); IR (film) 1625, 1560, 1534 cm^{-1} (tropone C=C, C=O), 1194, 1114 cm^{-1} (C-O); ^1H NMR ($CDCl_3$) δ 1.10-2.18 (8H, m), 2.41-2.88 (4H, m), 3.63-3.77 (4H, m), 3.42(1H, m), 7.02(4H, s-like); ^{13}C NMR ($CDCl_3$) δ 18.6, 20.0, 24.1, 27.5 (each t, $-CH_2-$ of cyclohexane ring), 42.1 (d, $-\overset{|}{C}H-$), 47.2 (t, $-CH_2-\overset{|}{N}-$), 66.9 (s, $-\overset{|}{\underset{|}{C}}-$), 66.9 (t, $-CH_2-O-$), 131.1, 132.2, 142.1, 142.9 (each d, =CH-), 151.4, 153.8 (each s, $=\overset{|}{C}-$), 187.7 (s, C=O). 5c, a yellow oil; MS m/z, 285.1700 (M^+, $C_{18}H_{23}NO_2$); UV (MeOH) λmax (log ε)

233 (4.21), 325 nm (4.04); IR (film) 1623, 1559, 1549, 1544 cm^{-1} (tropone C=C, C=O), 1202, 1113 cm^{-1} (C-O); ^{1}H NMR ($CDCl_3$) δ 0.92-2.15 (10H, m), 2.52-2.73 (4H, m), 3.50 (1H, m), 3.63-3.78 (4H, m), 6.97 (4H, s-like).

The reactions of 1 with 6-methyl-1-morpholino-1-cyclohexene[9)] gave an adduct, 9 (20 %)[10)] and with a mixture of 3-methyl- and 5-methyl-1-morpholino-1-cyclohexene[11)] gave an adduct, 10 (30 %)[10)] as an isolated product; however, at present under the similar conditions no cycloadducts of 1 with the enamines other than those descrived above were obtained.

It was reported that in a benzocycloalkene series, ring strain gives rise to a general increase in the intensities of the absorptions, basically assigned to forbidden transitions for benzene,[12)] whereas almost unchanged electronic spectra of 5a,b,c, 9, and 10, compared with those of 1,4-methano-1,2,3,4-tetrahydro-7H-benzocyclohepten-7-one (11),[2c)] show that a structural modification of tropone skeleton such as a fusion of cyclobutene at C-4 and C-5 has little effect on the conjugation of π system.

On the other hand, ^{1}H NMR spectra of 5 exhibit singlet-like signals of the protons on the tropone ring as described above, indicating that, in comparison with the chemical shifts of troponoid protons of 11 (protons α to the fused ring: δ 7.18 ppm. β protons : δ 6.96 ppm),[2c,13)] those of troponoid protons β to the fused cyclobutene remain unchanged, while those of α protons move to high field by 0.1 - 0.2 ppm. These deshielding effects are similar to the NMR behavior of strained benzocycloalkenes.[15)]

Further studies on the electrophilicities of 4,5-dehydrotropone (1) are now in progress.

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3) In the oxidative conditions for generation of 1, some adducts(e.g., ene reaction products) would be susceptible to oxidation. In the reactions of 1 with trapping reagents such as 1,3,5-cycloheptatriene, dihydropyran, and 6,6-dimethylfulvene, no adducts were isolated. These results also would arise from the instabilities of those olefins or the adducts in the reac-

tion conditions.

4) N. G. Rondan, L. N. Domelsmith, K. N. Houk, A. T. Bowne, and R. H. Levin, Tetrahedron Lett., 1979, 3237.

5) 7a : colorless needles, mp 138-140 °C. 8a : colorless needles, mp 147-148 °C.

6) Treatment of a tetrahydrofuran solution of 2 and 3 with enamine 4a gave 7a and 8a. Owing to the lability of the enamines in the reaction conditions, treatment of a dichloromethane solution of 2, 3 and the enamine with insufficient amount of lead tetraacetate led to increased yields of 7 and 8. 7b : colorless microprisms, mp 124-125 °C. 8b : colorless needles, mp 104-105 °C.

7) R. F. Parcel and F. P. Hauck, Jr., J. Org. Chem., 28, 3468 (1963).

8) 6: pale yellow needles, mp 89.5-91.5 °C; UV (MeOH) λmax (log ε) 226 (4.18), 275 (3.43), 368 nm (4.18).

9) G. Stork, A. Brizzolara, H. Landesman, J. Szmuszkovics, and R. Terrell, J. Am. Chem. Soc., 85, 207 (1963).

10) 9: a pale yellow oil; MS m/z, 285 (M^+); UV (MeOH) λmax (log ε) 232 (4.27), 326 nm (4.07); IR (film) 1621, 1557, 1530 cm^{-1} (tropone C=C, C=O), 1195, 1117 cm^{-1} (C-O); ^1H NMR ($CDCl_3$) δ 1.04 (3H, d, J=7 Hz), 1.55-2.20 (7H, m), 2.20-2.90 (4H, m), 3.45 (1H, m), 3.62-3.77 (4H, m), 7.00 (4H, s-like); ^{13}C NMR ($CDCl_3$) δ 16.6, 17.7, 22.9, 26.6, 30.8, 40.7, 47.2, 67.3, 72.1, 132.5, 132.9, 141.5, 143.2, 152.1, 152.7, 188.3.

10: a pale yellow oil; MS m/z, 285 (M^+); UV (MeOH) λmax (log ε) 232 (4.18), 325 nm (3.98); IR (film) 1625, 1562, 1547, 1537 cm^{-1} (tropone C=C, C=O), 1197, 1113 cm^{-1} (C-O); ^1H NMR ($CDCl_3$) δ 0.87 (3H, d, J=5.5 Hz), 1.12-2.29 (7H, m), 2.37-2.85 (4H, m), 3.54 (1H, bd, J=7 Hz), 3.67-3.77 (4H, m), 7.01 (4H, s-like); ^{13}C NMR ($CDCl_3$) δ 22.6, 27.0, 29.7, 32.0, 40.7, 41.1, 47.4, 66.5, 67.1, 131.0, 132.3, 143.0, 143.2, 150.2, 156.4, 188.1.

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13) Chemical shifts of troponoid protons of 11 were assigned by comparison of those of the bridged tropones reported in ref. 2a and 2c and those of 5-bromo-5,11-dihydro-5,11-o-benzenocyclohepta[b]naphthalen-8-one, an adduct of 1 with 9-bromoanthracene,[14] in which chemical shifts of troponoid protons corresponding to β and α protons are δ 6.94 and δ 7.43, 8.10 respectively.

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